MANAGEMENT OF BEECH BARK DISEASE IN AFTERMATH FORESTS

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Abstract

From two lines of investigation, it is apparent that on sites typical of the north-central and eastern regions in Maine, where beech bark disease has been present for over seventy years, achievement of a balanced species composition will be difficult realize. The first line of inquiry was followed using an historical approach. Stands subjected to varying harvesting intensities were evaluated 20 to 30 years after the harvesting. Documentation of changes in beech composition and growth was recorded. The second study comes from a direct application of treatments, with species changes documented as time progressed. Initially a USDA Forest Service study, this project was evaluated again after a period of ten years. In both studies, beech continues to be a dominant and sometimes aggressive occupier of sites, regardless of harvesting treatment. While some data show that beech presence can be statistically different initially, depending on harvesting treatment, significant biological gains in maintaining or improving a balanced species composition will likely take several cutting cycles, if not rotations. The clear implication is that, in order to efficiently recover the productivity potential of these sites in a timely manner, additional silvicultural techniques need to be applied to the standard harvesting regimens currently practiced.

Introduction

The beech bark disease, a disease complex resulting from the interaction of an insect, *Cryptococcus fagisuga* Lind., and one of several fungal pathogens of the genus *Neonectria*, has been occurring on American beech (*Fagus grandifolia* Ehrh.) in North American forests for approximately 100 years. Three stages of disease progression have been characterized by Shigo (1972). The first stage is described as an advance front, where the presence of only the beech scale insect occurs. Following the development of high populations of scale, and usually after a period of approximately ten years or more, a killing front stage occurs. In the killing front, *Neonectria* fungi invade bark tissues predisposed to infection by the feeding activities of the beech scale. Widespread beech mortality then often occurs. Forest areas that have experienced the killing front stage, and have continued to develop for a long time period in the presence of both the scale insect and the pathogenic *Neonectria* fungi, are often referred to as aftermath forests. Aftermath forests are structured differently than pre-disease forests (Houston 1975). Most large, susceptible beech have been killed by the disease, leaving canopy gaps of various sizes, depending on the distribution of the beech in the original stand. Root systems of beech stems killed by the disease can sprout into dense thickets, thereby perpetuating the susceptible genotypes. Usually, scale populations are much lower than populations that occur in advance and killing front zones. As a result, beech stems that are small and highly defective characterize aftermath forests. These stems have numerous localized cankers of the beech bark disease. Usually these lesions are deep, since cankers were initiated when stems were small, and persist throughout the life of the trees, which typically survive for decades. Often, the percentage of beech in disease-affected stands increases as a result of the root sprouting capacity of the species (Houston 1975). This shift in species composition tends to leave stands in aftermath areas less biologically diverse, with stems of much lower value occupying considerable stand growing space. The end result is that stands affected by beech bark disease eventually support a decrease in overall stand productivity and value, placing a considerable cost on forest management to modify or correct the problem.

In Maine, the disease has been know to occur for over 70 years, with the killing front occurring throughout much of the region during the 1940’s and 1950’s. Early attempts to manage the disease were largely restricted to sanitation or salvage cutting of beech in disease-affected stands. Forests in northern and eastern Maine regions have experienced the most severe damage from the disease (Laustsen *et al.* 2003). This is based on current field observations of the degree of stem cankering on existing beech, beech mortality, and the relative proportion of beech in the stands.

The proportion of beech in many hardwood stands has increased over the past several decades. Manipulation of species composition is often a desirable goal of stand harvesting activities. Finding suitable harvesting protocols that allow foresters to control beech regeneration and beech thicket development could greatly reduce the effect of beech bark disease in future stands. This report summarizes information from two specific studies on effects of harvesting intensity and harvesting season on silvicultural success in improving species composition in hardwood stands. The use of some intermediate silvicultural practices on controlling stem abundance of susceptible beech is also included. The findings are most applicable to sites and stands considered typical the north-central and eastern regions of Maine, but the management dilemma may be typical to other areas where aftermath forests have developed.

Methods

Overstory density effects on growth of American beech were studied in the eastern region of Maine by Patton (1997). In this study, twenty sites were chosen from continuous forest inventory (CFI) plots that had been established in the 1950s, and measured every five years. The twenty sites were grouped into four treatments each representing one of the following harvest level intensities: light partial harvest, heavy partial harvest, clearcut, and an uncut control. Harvest intensity was described by residual overstory basal area per acre (BA/A) immediately following the harvest from data supplied by the CFI records. Light harvests had greater than 60 ft^2 BA/A, heavy harvests had between 21 – 59 ft^2 BA/A, clearcuts were commercial clearcuts, where some unmerchantable trees were left, but where residual basal area was less than 5 ft^2 /A. Drainage class was determined for each site based on soil depth to mottling, as described by Briggs (1994). Three plots per site were used to assess current overstory density using a 10-factor cruising prism, and an additional three 0.01 acre circular plots were used to characterize the understory at each site. The circular plots were centered on the prism plot centers. Species, diameter at breast height (dbh), crown class, and total height were recorded for all understory trees and overstory trees.

The second study was established by the USDA Forest Service in 1991 in a beech stand in north-central Maine. Details of this study have been described by Houston (2001). The study area is dominated by American beech, but also includes some sugar maple (*Acer saccharum* Marsh.), yellow birch (*Betula alleghaniensis* Britton), red maple (*Acer rubrum* L.), striped maple (*Acer pensylvanicum* L.), and white ash (*Fraxinus americana* L.). While initial total basal area varied between plots, beech represented between 70 to 85 percent of the basal area. The study consists of 15 ten-acre forest blocks to which various harvest treatments were applied. Three blocks received a winter partial harvest, three received a summer partial harvest, three were clearcut in winter, three were clearcut in summer, and three were left as uncut controls. Overstory and understory data were also collected by standard sampling methods, as described (Houston 2001).

In 2002, ten growing seasons after the initial harvest treatments were conducted, the original overstory and understory plots were located and again measured for forest stand and tree characteristics by Farrar (2003). Data on overstory composition and structure were obtained using point samples centered on five points in a diagonal transect set across each 15-acre plot. Data on understory regeneration were obtained from nested 1-m and 2-m (39 and 78 in. diameter) plots centered on the middle three sample points of each transect.

Results and Discussion

Harvesting methods that could reduce or discourage beech regeneration from developing in managed hardwood stands would allow increased productivity and improved overall health of aftermath forests. Using a historical approach at the eastern Maine sites, Patton (1997) found that harvest intensity had little effect on beech establishment and subsequent species composition percentage from twenty to thirty years after the harvest. The following percentage of beech, averaged across five sites in each of the four harvest intensities examined, showed the following: uncut stands, 26 percent; light partially harvested stands, 21 percent; heavy partially harvested stands, 29 percent; and in clearcuts, 22 percent. Although there was some variation from site to site within treatments, no clear trend can be drawn for making a case that harvesting intensity alone has a significant management effect on subsequent beech regeneration and development. Although most eastern Maine sites examined were moderately-well to well drained, drainage class was variable on sites within treatments, so no trends could be surmised. However, general soil and site conditions may have a significant influence on the aggressiveness of beech regeneration. One hypothesis is that the more fertile, moist but well-drained sites can more readily support higher value hardwoods, such as yellow birch, sugar maple, and white ash. Site relationships in aftermath forests, and in other regions of the range of beech as well, could provide useful insights in predicting the likelihood of significant composition changes following beech bark disease.

In the experimental approach used by Houston (2001) at the north-central Maine site, a similar finding regarding harvesting effects was reported. Four years after study initiation, differences in beech regeneration of seedlings and root sprouts between the harvest treatments had disappeared. In general, beech regeneration developed more abundantly in the summer clearcut harvest, but had lower survival rates that those that developed after the winter clearcut harvest. Thus, total numbers appeared to equalize. Farrar (2003) found that ten years after harvest, beech understory survival in winter clearcut blocks was 41percent, and in winter partial cut blocks was 48 percent, a difference that was not statistically significant. However, beech survival in the summer clearcut blocks was 27 percent, compared with survival of 36 percent in the summer partial cut blocks. Thus the trend of higher mortality occurring in summer clearcut blocks appeared to continue throughout the ten-year period. Unfortunately, while these values were statistically different, survival of 27 percent of beech stems still provides a more than adequate supply of regeneration to dominate as the principal stand component over time. Clearcutting does provide, however, the opportunity for faster growing shade intolerant species to develop, such as paper and yellow birch (Patton 1997). While beech may be a significant component of these stands, the shade intolerant stems can out-compete the beech in height growth, and will improve stand species composition to some degree.

If clearcutting can marginally influence species composition by reducing beech regeneration, other silvicultural precautions need to be considered. In particular, Farrar and Ostrofsky (*manuscript accepted and in revision*) have described some unintended consequences of leaving beech resistant to the beech scale in stands that were subsequently clearcut. Leaving beech resistant to the beech scale is recommended to preserve a relatively reliable source of mast for wildlife interests, as well as to preserve the resistant genotypes in the landscape. Resistant American beech of high vigor left in clearcuts without the protection of surrounding trees were highly susceptible to decline and death from exposure. The results of this study has shown that in clearcut blocks, resistant trees that were left standing suffered mortality ranging from 67% - 78% by the end of the ten-year period. There was no mortality of resistant trees left standing in any of the partially cut blocks or in the no-cut control blocks. Management guidelines to characterize minimum buffer requirements for leaving resistant trees in clearcuts, and even in heavy partial cuts, would be an important addition to management of hardwood stands in aftermath forests.

Based on these studies, and from other field observations of the aggressive nature of beech regeneration following a wide range of harvesting alternatives, it is clear that the use of harvesting protocols alone will not realistically improve the long-term composition of the aftermath forests in Maine. As further indication, Bohn and Nyland (2003) have reported that the likelihood is low of changing understory composition in stands with high proportions of beech, a characteristic of aftermath forests, following partial cutting in uneven-age stands in New York. Filip (1978) reported little change in overstory representation of beech following several cutting cycles of a selection system applied in New Hampshire, as well.

Additional, intermediate silvicultural methods are likely to be more efficient and cost-effective in the long run. Timber stand improvement work using herbicides or mechanical methods have been shown to be effective vegetation management alternatives (Horsley and Bjorkbom 1983, Kochenderfer *et al.* 2001, Ostrofsky and McCormack 1986, Ostrofsky and Houston 1988). While initial costs will be higher than when managing stand composition strictly with harvesting methods, the benefit of reclaiming lost site productivity within a single rotation may far outweigh the costs.

Stand conversion practices, heavy cutting prescriptions, and the use of herbicides can help shift stand composition away from defective beech towards more favorable species (Mielke *et al.* 1986) However, such practices are not acceptable alternatives in all stand situations, or for all ownerships. Individual stem treatment methods offer good potential for improving beech-dominated stands that have not yet been severely degraded in composition. This approach may also prove useful in stands where relatively high numbers of resistant beech occur. The selective removal of only the most susceptible and most debilitated stems requires a method that can be applied on a stem-by-stem basis. Direct mechanical stem girdling has been shown to be an effective way to kill small (up to 5 in. diameter) beech stems (Nyland 2004). Mechanical girdling may be most efficient when used on beech stems that have not had extensive localized cankering of the bark. In aftermath areas of Maine, most beech stems, including small saplings one inch in diameter or less, often support extensive, deep cankering. Stems with deep cankers may require more effort to girdle mechanically, requiring a deeper cut, or effectiveness may be reduced.

Stem girdling with the use of heat is another alternative. Heat applied to the bark of undesirable stems will kill cambial tissues, resulting in girdling and tree death. This method has been tested in eastern Maine. One hundred beech stems in each of two diameter classes (0.5 in – 2.5 in.; 2.6 in. – 4.5 in.), and 75 beech stems 4.6-6.5 in. diameter at each of two sites were girdled in mid-March using a propane burner. The burner consists of a commercially available propane torch, with a backpack-mounted tank. Stems were girdled at about three feet from the ground. Observations have shown that treated trees die over an extended period of time. Virtually all treated trees produced leaves during the spring of treatment, and most re-foliated again the following spring, as well. When a sample of girdled stems was inspected by removal of bark, all trees were effectively girdled. Most showed evidence of stem swelling above the girdle, and epicormic sprouting immediately below the girdle. There was no observed root sprouting resulting from the treatment for up to three years following the treatment, the duration of the study.

Control was most effective in the smaller stem size classes. One explanation for the lack of root sprouting observed was that because the trees re-foliated, energy reserves stored in the roots were slowly depleted. These reserves could not be replaced due to the interruption of phloem at the girdle. In addition, the occurrence of a "slow kill" may be beneficial in small woodlot ownerships, or where aesthetically sensitive sites need treatment. The technique does offer an alternative to the use of herbicides, which some landowners find unacceptable. Drawbacks of the method include the labor-intensive application of the treatment, especially in large areas, or where sprout stems of beech are too numerous. Further testing seems warranted.

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Literature Cited

Bohn, K.K., and R.D. Nyland. 2003. **Forecasting development of understory American beech after partial cutting in uneven-aged northern hardwood stands.** Forest Ecology and Management 180:453-461.

Briggs, R.D. 1994. **Site classification guide.** Cooperative Forestry Research Unit Technical Note 6, Pub. 724. 15 pp.

Farrar, A. 2003. **Ten years of change in a beech stand in north central Maine long affected with beech bark disease.** M.S. Thesis, Univ. Maine, Orono. 55 pp.

Farrar, A., and W.D. Ostrofsky. **Dynamics of American beech regeneration ten years following harvesting in a beech bark disease affected stand in Maine.** North. J. Appl. For. (*manuscript accepted and in revision*)

Filip, S.M. 1978. **Impact of beech bark disease on uneven-age management of a northern hardwood forest.** USDA Forest Service General Technical Report NE-45. 7pp.

Horsley, S.B., and J.C. Bjorkbom. 1983. **Herbicide treatment of striped maple and beech in Allegheny hardwood stands.** Forest Science 29(1): 103-112.

Houston, D.R. 1975. **Beech bark disease: The aftermath forests are structuredfor a new outbreak.** Journal of Forestry 73: 660-663.

Houston, D.R. 2001. **Effect of harvesting regime on beech root sprouts and seedlings in a north-central Maine forest long affected by beech bark disease.** USDA Forest Service Research Paper NE-717. 20 pp.

Kochenderfer, J.D., S.M. Zedaker, J.E. Johnson, D.W. Smith, and G.W. Miller. 2001. **Herbicide hardwood crop tree release in central West Virginia.** North. J. Appl. For. 18:2:46-54.

Laustsen, K.M., D.M. Griffith, and J.R. Steinman. 2003. **Fourth annual inventory report on Maine's forests.** Dept. of Conservation, Maine Forest Service. 38 pp.

Mielke, M.E., D.R. Houston, and A.T. Bullard. 1986. **Beech bark disease management alternatives.** p. 272-280 in Proc. Integrated Pest Management Symposium for Northern Forests. Univ. Wisconsin, Coop. Ext. Serv., Madison.

Nyland, R.D. 2004. **Simple girdle kills small American beech (*Fagus grandifolia* Ehrh.)** North. J. Appl. For. 21:4:220-221.

Ostrofsky, W.D., and D.R. Houston. 1988. **Harvesting alternatives for stands damaged by the beech bark disease.** pp. 173-177 in Proceedings, 1988 Society of American Forester's National Convention, SAF Publ. 88-01.

Ostrofsky, W.D., and M.L. McCormack, Jr. 1986. **Silvicultural management of beech and the beech bark disease.** Northern Journal of Applied Forestry 3: 89-91.

Patton, T.A. 1997. **Effects of overstory density and beech bark disease severity on height growth patterns of American beech and associated species.** M.S. Thesis, University of Maine, Orono. 98p.

Shigo, A.L. 1972. **The beech bark disease today in the northeastern United States.** Journal of Forestry 70: 286-289.

Evans, Celia A., Lucas, Jennifer A. and Twery, Mark J. 2005. **Beech Bark Disease: Proceedings of the Beech Bark Disease Symposium.** Gen. Tech. Rep. NE-331. Newtown Square PA, US. Department of Agriculture Forest Service, Northern Research Station. 149 p.

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